

DENTAL microwear in *Griphopithecus alpani*.  
KING, T. C. Human Origins Group, Department of  
Palaeontology, the Natural History Museum, London  
SW7 5BD, UK.

This study examines the molar microwear of *Griphopithecus alpani*, a 15 Ma hominoid from north-western Turkey. Inferences can be made about the diet of extinct species by comparing their microwear patterns with those of present-day taxa whose diet is known. The microwear patterns of *Griphopithecus alpani* were compared to three extant hominoid taxa - *Gorilla gorilla gorilla*, *Pan troglodytes verus*, and *Pongo pygmaeus pygmaeus*. Three occlusal surfaces on each molar were examined using a scanning electron microscope in back-scattered mode. Microwear features were analysed using a digitizer and software especially developed for microwear studies.

The following results are indicated: 1) there are consistent variations between the different facets examined in this study. These differences relate to the two phases of the chewing cycle; 2) *Griphopithecus alpani* is more similar to *Pongo* in its microwear patterns than to the other extant species. No significant differences between these two species were indicated for any microwear variable examined in this study; 3) *Griphopithecus alpani* displays high percentages of pits relative to the extant hominoids. It is suggested that *Griphopithecus alpani* ingested harder fruits and/or objects than the present-day species. In this respect *Griphopithecus alpani* is similar to *Graecopithecus freybergi*, a later Miocene hominoid.

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Dental evidence for cheirogaleid affinities. E.C. KIRK and B.A. WILLIAMS, Biological Anthropology and Anatomy, Duke University, Durham, NC 27710.

Due primarily to biogeographic considerations, taxonomists have traditionally considered all Malagasy strepsirrhines to constitute a monophyletic group. However, some researchers in the late 1970's suggested that cheirogaleids are more closely related to African and Asian lorids than to other lemurs on the basis of several shared features of cranial anatomy. Yoder (1992, 1994) investigated the question of cheirogaleid relationships using a cladistic analysis that incorporated both morphological and molecular data. Though her molecular data strongly supported Malagasy strepsirrhine monophyly, her morphological data provided much weaker support for a cheirogaleid-lemurid clade. This study seeks to augment the morphological work of Yoder and shed further light on the relationships of the Cheirogaleidae through an intensive cladistic analysis of strepsirrhine dental characters.

In the first analysis, 81 characters were scored for 19 taxa using original dental material or high-resolution casts. Maximum-parsimony trees were generated using the heuristic search option in PAUP Version 3.1.1. Characters were polarized using an OTU derived from studies of primitive adapiform and omomyiform dentitions. In a second analysis, our dental data were combined with Yoder's skeletal data for the 16 strepsirrhine taxa shared in

common by the two studies and a second set of maximum-parsimony trees were created.

In both analyses, cheirogaleids fall at the base of the most parsimonious consensus tree, with the genera *Microcebus* and *Mirza* forming a basal polytomy with the hypothetical ancestor. This basal positioning of cheirogaleids neither supports nor contraindicates Malagasy monophyly. Loroids form a monophyletic group that is strongly supported by high bootstrap values and is easily diagnosed by a number of dental synapomorphies. Cheirogaleids are seen to share none of these distinctive loroid dental features and appear to be persistently primitive in most aspects of their anatomy. These findings agree with the observations of others who have noted that the postcranial anatomy of many primitive Eocene euprimates closely resembles that of cheirogaleids. We suggest that, of all living strepsirrhines, cheirogaleids most closely approach the ancestral crown strepsirrhine morphotype. The distinctly plesiomorphic nature of most aspects of cheirogaleid anatomy is likely responsible for the inability of morphological cladistic approaches to decisively resolve questions regarding cheirogaleid phyletic affinities.

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Multivariate probit analysis of deciduous dental emergence. L.W. KONIGSBERG, Anthropology Dept., University of Tennessee, Knoxville, TN 37996, D.J. HOLMAN, Anthropology Dept., Pennsylvania State University, University Park, PA 16802, and R.E. JONES, Center for Demography and Ecology, University of Wisconsin, Madison, WI 53706.

Probit and survival analyses have become common methods for studying the timing of dental eruption. Previous studies either have been limited to univariate analyses, or have treated individual teeth as if they emerge independently of one another. The appropriate method for analyzing multiple tooth emergence is a multivariate probit model that includes all variance-covariance terms. Although this model is well known in the statistical literature, it is difficult to implement because of the need for high dimensional integration. We approach this problem using a Markov Chain Monte Carlo (MCMC) method to analyze mixed longitudinal and cross-sectional data on deciduous dental eruption status.

We use deciduous dental eruption data from 1,271 rural Guatemalan, 397 rural Bangladeshi, 468 rural Javanese, and 114 urban Japanese children (previously reported in Holman and Jones, AJPA Suppl. 20:113). We fit a multivariate probit model with separate mean eruption ages by tooth for each population, and a pooled within-group covariance matrix among teeth. This model is fit conditioning on previously simulated eruption times for all other teeth. We also describe a MCMC method for calculating the full posterior density function for developmental age conditional on observed eruption status. This method is asymptotically exact, and can easily accommodate incomplete observations typical of those found in forensic or archeological contexts.

Our results show that there is considerable correlation among dental eruption times. Consequently, the oft-cited assumption of "conditional independence" cannot be

invoked when assessing dental emergence. We also show that morphological "field effects" for the dentition are reflected in the covariance between eruption times of individual teeth.

Social system dynamics, ranging patterns and male and female strategies in wild Bornean orangutans (*Pongo pygmaeus*). C.D. KNOTT, Department of Anthropology, Harvard University, Cambridge, MA 02138.

Orangutans are primarily solitary, have relatively low population densities and seem to range over large areas. These features have made a complete understanding of their social system particularly difficult. Descriptions of the orangutan social system have ranged from "large groups of individuals traveling together" to "exclusive male territories encompassing overlapping female territories." This study attempts to reconcile these various descriptions as well as present a new model of the orangutan social system, showing how temporal and spatial distribution of fruit, female reproductive patterns and varying male strategies are critical determinants of orangutan social patterns. The research was conducted on wild orangutans in Gunung Palung National Park, Indonesian Borneo. It is based on over 10,000 observation hours between August 1994-1997.

Orangutans at Gunung Palung were subjected to significant fluctuations in fruit availability during this period. These ranged from supra-annual "mast" fruitings when a large number of tree species fruited in synchrony, to periods of significant fruit shortage, and annual fruit peaks of individual species. Such fluctuations had a significant impact on orangutan diet, caloric intake and female hormonal levels. Orangutan distributions and social behavior varied dramatically in accordance with these changes.

During the "mast" period of highest fruit availability as many as 6 large males could be found using overlapping ranges. These males were concentrated in areas with both high fruit availability and the presence of cycling females. Traveling and feeding parties of adult females with offspring and of sub-adult males also occurred. Aggression increased between fully developed males. All matings occurred during periods of relatively high fruit production. These patterns were also seen during smaller fruit peaks, but on a less pronounced scale. During low fruit periods, animals were primarily solitary, no matings were observed and the number of males using the study area was reduced.

Distribution patterns and social and reproductive strategies differed between sub-adult and fully adult males (those with cheek pads). Analysis of urine revealed that adult males had higher levels of infection due to wounds received from fights with other males. Urinary testosterone levels were measured using radioimmunoassay showing that "sub-adult" males had significantly higher testosterone levels than did fully developed males. The implications of this for interpreting male strategies will be discussed.

This research was supported by the National Geographic Society, the L.S.B. Leakey Foundation, the Wenner-Gren Foundation, Harvard University and NSF.

A comparison of mortality in a native and an immigrant community in southwestern Hungary. T.A. KOERTVELYESSY, Ohio University, Athens, OH 45701.

Mortality is affected by such variables as individual biological

constitution, gender, ethnicity/nationality, age, family and socioeconomic group membership, as well as the various factors of the natural environment, economic development/technological change, and advances in medicine and public health programs. Mortality, thus, is governed by both biological and socioecological forces. The objective of this work is to examine neonatal, infant, and pre-reproductive mortality in two historical populations (one native Hungarian, the other immigrant German) from SW Hungary for the period 1800-1895. Previous work (Koertvelyessy and Nettleship, 1996), using isonymy-based genetic distance information, identifies the two populations (ACSA and Miklosi) selected for this analysis as the two genetically most distinct villages.

The obtained results indicate that neonatal mortality constitutes about 16% of all deaths, with some slight differences between populations and between sexes. With the exception of Hungarian males (34%), infant mortality represents about 31% of the total deaths, with the Hungarian male and female differences being significant ( $\chi^2=5.36$ ; 1 df;  $P<0.05$ ). In addition, pre-reproductive mortality is relatively high at about 65% of all deaths, with the exception of Hungarian males where it is nearly 67%. These values indicate similar general health and hygiene status in the two populations; the possibility of high selection potential; and the absence of any significant ethnic influence on mortality regimes in these villages.

Quantification and Extraction of Tetracycline in Ancient Nubian Bone From the X-Group Period (350-550 CE) K. L. KOHLBACHER SUNY Binghamton, K. Roux and G. J. Armelagos Emory University, Atlanta GA 30322

The presence of tetracycline, a broad-spectrum antibiotic, in ancient Sudanese Nubian bone has been well documented. Collins and Armelagos (1997) determined that 8.8% of the 51,008 intact osteons were labeled in an X-Group population (NAX) dated from 350-550 CE). Collins and Armelagos considered only labeled intact osteons and did not measure labeling in other histological categories. Measuring just the intact osteons represents the most recent incorporation of tetracycline, while quantifying all labeled bone indicates longer-term incorporation. In this study all histological features such as hyper density inter-lamellar bone, lamellar bone, and fragments as well as intact

fluorescent osteons were counted in femoral cross sections of 56 individuals. On the average, 5.9% of the bone including all histological features were labeled. Labeled bone within the population varied from 0.6% to 25%. Fifty percent on the individuals had 1% to 4.99% labeling and 33.4% showed the 5 to 9.99% labeled bone.

The second phase of this research entailed the extraction of tetracycline from EDTA decalcified bone using methanol or ethanol. Extraction of tetracycline is compared with the histological quantified labeling to determine the amount of tetracycline sequestered in bone and to test its biological activity.

A quantitative comparison of preoperative dysmorphology in metopic and sagittal synostosis. J.C. KOLAR, Columbia Craniofacial Center, Medical City Dallas, and E.M. SALTER, The University of Texas at Dallas.

Metopic and sagittal synostosis both involve premature closure of midline sutures of the cranial vault. Sagittal synostosis is the most common form of craniosynostosis, representing more than half of all reported cases, while metopic synostosis is one of the rarest. Recent studies have shown complex patterns of dysmorphology throughout the craniofacial skeleton in both synostoses. These suggest some similarities in dysmorphology, especially in the face, despite marked differences in cranial vault form.

To compare quantitatively the dysmorphology associated with these midline synostoses, 99 preoperative patients with a diagnosis of primary (non-syndromal) craniosynostosis were examined using a battery of 24 anthropometric measurements from which 11 proportion indices were calculated. The patient pool consisted of two subsets, 49 patients with sagittal synostosis (40 males, 9 females) and 50 with metopic synostosis (38 males, 12 females). The measurements and proportions for each patient were compared to sex- and age-matched normal standards and converted to standard (Z) scores. The data for each variable were pooled separately for each subset before being compared using a two-sample t-test.

The data show significant differences in cranial vault size and shape. Sagittal synostosis patients have generally larger heads, with the exception of biparietal breadth. The forehead is narrow in metopic synostosis and wide in sagittal. Both groups show similar reductions in cranial vault height related to their synostoses. The faces of patients with sagittal synostosis tend to be larger than those with metopic synostosis, though most of the differences are not significant. The facial contours are significantly larger in sagittal synostosis. Both groups show similar increases in sagittal growth throughout the face. Both exhibit significant narrowing of the intercanthal space, though this is marked greater in patients with metopic synostosis.

The similarities in facial size and shape suggest similar

mechanisms of redirected growth resulting from constraints on lateral growth due to midline suture closure.

Pitfalls of Ancient DNA Analysis in New World Human Populations. C.J. KOLMAN and N. TUROSS, Smithsonian Institution, Conservation Analytical Laboratory, 4210 Silver Hill Road, Suitland, MD 20740

Amerind groups were first haplotyped for mitochondrial DNA (mtDNA) restriction fragment length polymorphisms (RFLPs) by Douglas C. Wallace and coworkers in the 1980s. These investigators defined four classes of haplotypes, each based on a single RFLP, that were present at varying frequencies in populations throughout the New World. The RFLP data were instrumental in guiding future molecular studies of indigenous groups in the Americas. Subsequently, varying frequencies of the four haplotype classes formed the basis of molecular support for the controversial three wave hypothesis of New World colonization. Thousands of New World individuals have now been assayed for mtDNA RFLPs and control region sequence, including work on four groups of Panamanian Amerinds (Kolman *et al.* 1995, 1996). With the advent of polymerase chain technology in the field of ancient DNA (aDNA), the application of these markers to prehistoric populations would seem obvious though perhaps not as straightforward as originally thought. The contamination problems associated with aDNA analysis transform a simple RFLP study from a high through-put project into an excruciatingly detailed analysis of individual samples prior to and during the actual marker assays. Some of the issues encountered in the analysis of a series of carefully excavated and well-described skeletal populations from South Dakota dating from 0-1850 AD include the following: 1) negative no-DNA controls do not ensure lack of contamination, 2) the complete set of defining RFLPs should be scored for each individual, 3) the presence of intact and digested bands in a restriction endonuclease reaction does not necessarily signify an incomplete digest but may reveal the presence of two DNAs, one of which is likely to be a modern contaminant, 4) DNA sequencing is necessary to corroborate RFLP results, and 5) extensive repetition in experimental design is necessary for quality control. The impressive database of mtDNA RFLP and control region sequence data in New World populations assures the merit of a project assaying these markers in ancient populations, but only if extensive precautions have been taken to ensure the accuracy and reliability of the results.

Encephalization and endocranial morphology in *Dryopithecus brancoi*: implications for brain evolution in early hominids. L. KORDOS, The Geological Museum of Hungary, H-1143 Budapest, Stefania út 14, and D.R. BEGUN, University of Toronto, Toronto, ON M5S 3G3, Canada.

Until recently only one specimen of Miocene hominoid was preserved with a sufficiently complete neurocranium to

provide an estimate of cranial capacity (Proconsul, KNM-RU 7290: Walker, et al., 1983). Now the gap in paleoneurological data between early Miocene primitive hominoids and Pliocene hominids has been partly filled by a new specimen of the early hominid (great apes and humans) Dryopithecus branchoi from the late Miocene of Rudabánya, Hungary. RUD 77 is sufficiently complete to estimate overall cranial length and two measures of neurocranial length. Predictions of cranial capacity in RUD 77 based on least-squares regressions of cranial capacity and cranial/neurocranial lengths in living hominoids range from 305-329 cc. Mean percentage predictor errors for all three regressions are under 10% and predictions of cranial capacity from observed cranial lengths all fall within 20% of the observed cranial capacities. RUD 77 also preserves enough of the left orbit to allow for an estimate of body weight from orbital area (Aiello and Wood, 1994; Kappelman, 1996). The resulting body weight estimates of 24.6-26.5 kg are consistent with the overall size of the specimen, and allow for an estimate of EQ, which ranges from 2-2.3, using the formulae from Martin (1981) and Kappelman (1996). These EQ estimates are well within the range of values for extant great apes and some australopithecines. At the same time, the endocranial morphology of RUD 77 is unlike that of living great apes, particularly in the morphology and relative size of the frontal lobes and in certain details of sulcal patterning. This suggests a de-coupling of brain size and brain morphology evolution in early hominids. Great ape and human relative brain size appears to have remained relatively stable until the appearance of Homo while brain morphology has evolved in both the living great apes and in humans.

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Nuclear gene diversity and the relative antiquity of human populations: studies with a Monte Carlo model. K.A. KÓREY, Dartmouth College, Hanover, NH 03755.

The reconstruction of human population history has been increasingly founded on global patterns of diversity documented in both the nuclear and mitochondrial genome. Expressed as tree topologies, such interpretations are often based on the genetic distances obtained among samples of constituent populations. Although earlier work with Monte Carlo simulations has shown that varied evolutionary scenarios and chronologies may all produce patterns of genetic variation similar to those actually observed, at least as measured by the distribution of genetic heterozygosity and distance within and between major geographical regions, a belief persists that the degree of allelic diversity indexes the relative antiquity of populations within such regions. This latter premise may also be critically examined by applying Monte Carlo methods to the problem.

A computer model was constructed to represent four major regions of the Old World (i.e., Africa, Central Asia, Europe, and Australasia), each region consisting of a variable number of populations of specified size. Incorporating gene flow, drift, and mutation, the simulation modeled the evolution of 500 hypothetical multiallelic loci in the nuclear genome. For simplicity, intraregional gene flow assumed an isotropic, two-dimensional stepping stone design, although rate

asymmetries marked gene exchange between regions. Allelic diversity was generated by random mutation such that each locus was limited to 20 alleles, while drift was simulated by randomly sampling multinomial distributions representing the allele frequency arrays. This simulation thus embodies, in effect, a neutral, infinite-allele model of evolution within selective constraints, with gene flow among geographically-structured subdivisions.

To begin each simulation, four founder colonies with uniform gene frequencies were allowed to migrate into all available regional spaces, so that at the outset no region's founders were either ancestral to or older than another's. The extent and pattern of all subsequent differentiation was governed by manipulating the parameters of population structure, the initial allelic frequency distributions, the period founding populations might be sequestered within a limited subregion, and so forth. The resultant patterns of simulated genetic variation broadly correspond to those observed, and several related indices of allelic diversity—including (1) the global distribution of rare or unique alleles and (2) the number of resident alleles—show "African" populations to be more varied. Such results challenge the reliability of allelic diversity as a marker of relative population antiquity.

Dimensions of the pterygomaxillary hiatus: Afro-Euro-American variability.

R.T. KORITZER and L.E. ST.HOYME  
Anthropology Department  
Smithsonian Institution  
Washington, D.C. 20560

The pterygomaxillary hiatus (pterygopalatine fossa: PF) created by lateral-anterior-superior cranial case expansion, is a focus of skull dynamics which when measured is better appreciated. We describe this hiatus, which contains maxillary artery and its distribution, a neural network (including the pterygopalatine ganglion) and part of the origins of the temporal and lateral pterygoid muscle. Medially, in the fossa, are found connective tissue with scattered muscle fibers associated with maxillary nerve.

The PFs, paired cavities behind the maxillae, communicate with the nasal cavity by the sphenopalatine foramina (SPF). To estimate the PF volume, the height, depth and width were measured, using a calibrated periodontal probe, and an algorithm derived from the product of the measurements. A second level algorithm also is used to estimate the SPF area. An index derived from the square root of foramina area divided by the cube root of PF volume is used.

The distribution of the area/volume indices of the first 80 Terry Collection fossae pairs measured (30 BM, 17 BF, 33 WM, 7 WF), shows definite sex and race differences.

Comparability of lunar age calculated from Fazekas and Kósa's data on diaphyseal lengths to lunar age assigned to the fetal collections prior to curation at the National Museum of Natural History. F. KÓSA, Albert Szent-Gyorgyi Medical University, Szeged, Hungary, A.K. HUXLEY, University of Arizona, Tucson.

In the past, numerous techniques have been used to assess the age of fetal remains, such as the external dimensions of the fetus (crown-heel (CH) length, crown-rump (CR) length and weight), presence or absence of specific external features (lanugo) and presence or absence of ossification centers. In the fetuses curated at the National Museum of Natural History, lunar age assessments were predominately made by early embryologists, such as F.P. Mall, and pathologists, notably J.H. Smith using the methods outlined above. Usually age and other pertinent data, such as ethnicity, sex and a few specific external measurements, were recorded on card catalogs by A. Hrdlicka for future reference. Since no further information is retained, it is difficult to reconstruct any aspect of external features prior to maceration. From previous study of the collection by the authors, we found that the ages identified on the catalog cards are inconsistent with the biological ages determined from the skeletons. The purpose of this paper is to investigate these discrepancies in an attempt to reassign more accurate catalogue ages to the specimens.

A total of 157 cranial and postcranial measurements were taken on 78 fetuses stored at the National Museum of Natural History. All available diaphyses were measured (humerus, radius, ulna, femur, tibia and fibula), individual lunar age was calculated from each diaphysis and an average diaphyseal lunar age was developed for each fetus. Ascribed age was taken from the card catalogs, reflecting the age reported at the time of curation. The two ages, lunar age from diaphyseal length and lunar age from external morphology prior to maceration, are compared to assess any discrepancy between lunar age assignments.

Of the 78 fetuses, 77 had diaphyses available for measurement and age determination. Of these, only 38 had pertinent data reported in the card catalog for comparison. The differences between age assignments were compared for these fetuses: 20 showed no difference between the different techniques, 11 had a one-month difference, 6 had a two-month discrepancy, and 1 had a five-month divergence. The average difference between lunar ages is 0.74 months, reflecting nearly a three week difference.

These findings are interesting for two reasons: the external measurements of these fetuses are no longer available for inspection; and the discrepancies between lunar age estimations can never be completely resolved from macerated fetuses collected over half a century ago. For these reasons, caution is urged when using collections with no photodocumentation, incomplete datasets and antiquated age and ethnicity assessments.

Preliminary paleoanthropological field research in West Java, Indonesia. A. KRAMER, Department of Anthropology, University of Tennessee, Knoxville, TN 37996-0720 and T. DJUBIANTONO, Archaeological Research and Development Center, Bandung, West Java, Indonesia.

This paper reports on the results of a field project initiated at two sites in West Java during June, 1997. Near the community of Rancah, approximately 500m NW of the confluence of the Cipasang and Cisodong Rivers, a 6-meter-deep profile was excavated that yielded *in situ* megafaunal remains. Forty km north of Rancah, near the village of Baribis, surface surveys and three 2 X 2 X 1 meter test-pits produced additional large mammal fossils.

The results of this past field season, in combination with surface surveys at the same localities in 1993 and 1995, have produced a megafaunal assemblage similar to that associated with fossil hominids from Central Java. In particular, the presence of hippopotamids, cervids, bovids and *Stegodon* (an extinct proboscidean) at Rancah and Baribis is reminiscent of the faunal elements typifying the

Ci Saat and Trinil H.K. faunal zones from Sangiran. The Trinil H.K. faunal zone marks the first appearance of hominids in Central Java. It is important to note however, that Java emerged from the sea from west to east, requiring mammals (including hominids) to migrate through western Java to reach the central and eastern portions of the island. This fact, in association with the fauna already recovered from our sites in West Java, encourages us that future fieldwork there has the potential to recover the first West Javan, and possibly the most ancient non-African, hominids yet found.

We intend to concentrate next summer's field efforts at Rancah, rather than at Baribis, because at the former: 1) the recovered megafaunal remains were more numerous and complete, 2) the stratigraphy was more clearly demarcated, 3) potentially datable tuffs were interdigitated with the fossil-bearing strata, and 4) local farmers reported that fossil hominids had been found while cultivating their fields (however, these claims have not yet been substantiated with physical evidence).

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The locomotion of *Australopithecus afarensis*: a dynamic analysis and comparison with modern humans. P.A. KRAMER, Dept. of Anthropology, The University of Washington, MS 353100, Seattle, WA 98195.

The defining characteristic of the hominid clade is bipedality and researchers have equated ancient forms of bipedality with modern human gait since the first clear evidence of bipedal australopithecines was unearthed over 70 years ago. But, is it reasonable to assume that all forms of hominid bipedality are the same, selected to optimize locomotion in similar environments? Recent research has suggested that the australopithecine form of bipedality was transitional between the quadrupedality of the African apes and modern human bipedality and, consequently, inefficient. Most attempts to evaluate the locomotor efficiency of the australopithecines have, unfortunately, relied on inferences drawn from comparative anatomy and on the empirical evaluation of extant hominoids with little rigorous mechanical analysis being applied. The locomotor anatomy of modern humans is typically taken as the most efficient; however, modern human anatomy is the product of selective pressures present in the particular milieu in which modern humans arose and it is not necessarily the only, or even the most efficient, bipedal solution possible. This report investigates the locomotor efficiency of *Australopithecus afarensis* as represented by AL 288-1, "Lucy." Using standard mechanical analyses, the osteological anatomy of AL 288-1 can be used in a dynamic model of a biped. Movement profiles can be applied to the model and the results of this analysis can then be used to predict the energy that Lucy used when locomoting bipedally at various velocities. This same procedure can be used with the anatomy of a modern human and the two can then be compared. What becomes most apparent is that Lucy is efficient at locomoting at slow walking speeds while modern

humans are better at higher walking speeds. In some circumstances, Lucy is *more* efficient at slow speeds than her descendants. The locomotor anatomy of *A. afarensis* may well have been optimized for a particular ecological niche—slow speed foraging—and is not a compromise or a transition. This analysis is another support for the developing picture of *Australopithecus* as a unique genus adapted to its particular ecological environment and not a genus *Homo* want-to-be.

**Influence of congenital craniosynostosis on coronal suture interdigitating length.** A.M. KREITHEN, University of Pittsburgh, Pittsburgh, PA 15260, A.M. BURROWS, Slippery Rock University, Slippery Rock, PA 16057, M.P. MOONEY, University of Pittsburgh, Pittsburgh, PA 15260, H.W. LOSKEN, University of Pittsburgh, Pittsburgh, PA 15260, T.D. SMITH, Slippery Rock University, Slippery Rock, PA 16057, M.I. SIEGEL, University of Pittsburgh, Pittsburgh, PA 15260.

Artificial cranial deformation has been shown to increase suture complexity (i.e., interdigitating length and sutural bone frequency), probably as a compensatory response to altered biomechanical forces. Recent work (Burrows et al., 1997) has demonstrated that synostotic rabbits also exhibited increased sutural bone frequency. The present study was designed to assess age-related changes in sutural interdigitating length in rabbit crania with familial nonsyndromic delayed onset craniosynostosis. The interdigitated length of coronal sutures in 78 6 and 18 week old New Zealand white rabbit skulls (normal in-colony [NI] controls, n=36; bilaterally or unilaterally affected rabbits with delayed onset coronal suture synostosis [DO], n=42). Coronal suture interdigitating length (pterior to bregma) was quantified using the NIH Image program. Results of a 2 x 2 ANOVA showed that there was a significant age x group interaction ( $F=5.45$ ;  $p<.05$ ) in mean sutural length. Between 6 and 18 weeks of age, NI controls showed a 37% increase in interdigitated sutural length, while DO rabbits showed only a 17% increase. Differences between groups in the present study may be the result of variations in biomechanical factors, such as increased intracranial pressure, altered dural tract vectors, or bony bridging of the sutures. Supported in part by grants from NIDR (DE010830), Children's Hospital of Pittsburgh, Plastic Surgery Educational Foundation (PSEF), and the Central Research Development Fund (CRDF), University of Pittsburgh. Measurements were obtained using the public domain NIH Image program developed at the U.S. National Institutes of Health.

Prehistoric human subsistence in tropical Southeast Asia: Isotopic evidence from Niah Cave. J.S. KRIGBAUM, Department of Anthropology, New York University, New York, NY 10003.

Niah Cave, in northern Borneo (Sarawak, Malaysia), has long been recognized as one of the most significant

late Pleistocene-Holocene archaeological sites in island Southeast Asia. In addition to the famous "Deep Skull," which may well date to 40,000 BP, a remarkable series of human burial remains was recovered from Niah's West Mouth that range in age from ca. 14,000 - 2,000 BP. These remains offer the opportunity to elucidate post-glacial dietary change among prehistoric hunter-gatherers inhabiting a dynamic tropical lowland setting. Environmental and cultural factors affecting human subsistence during this period are examined based on new stable isotope data (carbon, nitrogen, and oxygen) derived from the human remains and associated fauna. Issues of bone diagenesis are considered in light of the difficulties in applying stable isotopic methods to prehistoric samples from the humid tropics.

Changes in sea level and climate clearly affected the distribution of food resources available to local foraging groups. Late Pleistocene-early Holocene levels at Niah indicate more seasonal forested conditions and increased distance from the coast, while later levels demonstrate closer proximity to the coast and the development of modern perhumid conditions. The introduction of particular cultigens in the Neolithic is an additional cultural factor affecting the diversity of foodstuffs available to later Holocene groups. Used in conjunction with the isotopic data, such archaeological and paleo-ecological evidence will allow inferences to be made about habitat-based and culture-based influences on dietary change among the late Pleistocene-Holocene inhabitants of Niah Cave.

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**ONTOGENY OF HUMAN AND AFRICAN APE DISTAL TIBIA: IMPLICATIONS FOR THE EVOLUTION OF BIPEDALITY.** C. A. KUNOS, S. W. SIMPSON, and B. LATIMER. Department of Anatomy, Case Western Reserve University and Laboratory of Physical Anthropology, Cleveland Museum of Natural History, Cleveland, OH 44106.

The kinematic and kinetic consequences of force translation in the lower limb during bipedal gait necessitate mechanisms which mitigate the deleterious effects of peak ground reaction forces. The unique cortical and trabecular organization of the human distal tibia represents an adaptation to these mechanical demands and is likely to be among a suite of skeletal features associated with obligate bipedality.

However, the pattern and timing of the acquisition of these characters remains unknown in hominoids. To explore the ontogeny of the distal tibia in humans and African apes, we examined a series of juvenile human longitudinal radiographs (Bolton-Brush Growth Study Center [n=12]), African ape longitudinal radiographs (n=1), and African ape cross-sectional radiographs (n=15) (Cleveland Museum of Natural History) to investigate internal morphological changes in the distal tibial metaphysis and epiphysis with age. The locomotor development of each BBGSC child at each age interval was available. The timing of the morphological changes in the human and ape groups was matched based on the pattern of dental development.

Children at birth and African ape juveniles display a similar oblique orientation of metaphyseal trabeculae relative to the physal line. African ape tibiae retain this orientation of the metaphyseal trabeculae into adulthood. However, children between one and seven

years demonstrate an increasing vertical orientation of the metaphyseal trabeculae and these changes increase with the developmental progression of gait. These changes in the internal morphology are associated with changes in the unique external morphology of the distal tibia. These features include increased metaphyseal flaring, a cuboid-shaped epiphysis, and increased flaring of a posterolateral tubercle supporting the epiphysis.

As such, forces imposed upon the talocrural joint during bipedality and quadrupedality contribute to the differential development and osteogenesis of morphological specializations in the distal tibia. These changes are meaningful in the context of hominid evolution.

**Female growth canalization: Do boys have more to lose?** C.W. KUZAWA, Emory University, Atlanta, GA 30322

Whether initially-stunted infants and children retain the capacity to catch-up relative growth deficits later in life is an unresolved question in international health and anthropology. The possibility that the capacity for catch-up growth varies by sex has not been systematically assessed, but is suggested by the anthropological literature on sex differences in developmental canalization. Published growth data from 50 populations are tested for sex differences in the relationship between height at 4 or 6 years of age and growth gain during later childhood and adolescence.

The results suggest that relative shortness during infancy and early childhood predicts distinct developmental trajectories in males and females. Among male cohorts, absolute height differences between populations at 4 or 6 years of age are amplified later in life, initially taller populations continuing to grow relatively more than their shorter counterparts, and vice versa. Male height differences between populations emerge throughout the growing years and appear to accrue at a rate proportionate to age-specific growth rates. In contrast, female populations relatively short at 4 years of age attain a greater percentage of their adult height after 4 years of age, leading to partial convergence in final standing height among female cohorts.

The general pattern that emerges is an amplification of initial between-population height differences among male cohorts, and a cross-population target range for body size among females. These observations are consistent with the notion of greater canalization of female body size, and suggest that catch-up growth may be more common among stunted female cohorts than among stunted male cohorts.

Laetoli Hominid 21: Comparative study of the morphology of the ulna. PELAJI S. KYAUKA, Department of Anthropology, San Francisco State University, CA 94132

Morphological features are widely used in taxonomic and phylogenetic

studies of fossil hominids, however very little is known about their ontogenetic morphology. This study compares the morphology of the proximal portion of the ulna of Laetoli Hominid 21 [L.H.-21(r)] with those of *Homo sapiens*, *Pan troglodytes* and *Gorilla gorilla* at similar stages of dental development. Letoli Hominid 21 is an immature hominid fossil attributed to *Australopithecus afarensis* (T.D. white, 1980, Am. J. Phys. Anthropol. 53:487-504).

Morphologically, the proximal portion of the ulna of modern *Homo sapiens* is different from those of the extant pongids at all ages. *Pan troglodytes* and *Gorilla gorilla* retain the largest coronoid processes, ulnar transverse, and ulnar trochlear notch diameters. L.H.-21(r) is closer to modern *Homo sapiens* than to either *Pan troglodytes* or *Gorilla gorilla* morphologically. In addition L.H.-21(r) appears to be very similar to specimen A.L. 288-1 attributed to an adult *Australopithecus afarensis*.

The morphological differences between the extant pongids and *Homo sapiens* are related to their locomotion patterns. The results suggest that L.H.-21(r) was unlikely used in body weight transmission and quadrupedal locomotion. Although the conclusion does not resolve the dispute regarding Laetoli Hominid 21's climbing ability, the results support the view that *Australopithecus afarensis* was a habitual biped.

A field investigation into the behavioral and food processing function of the cercopithecine cheek pouch. J.E. LAMBERT, Department of Zoology, University of Florida, Gainesville 32611.

Reports of cercopithecine cheek pouch use and functional significance are largely anecdotal, and, to date, there has only been one major inquiry into the evolution of this structure (Murray, 1975). The dearth of investigation into the adaptive and evolutionary importance of this anatomical feature is striking given that cheek pouches are generally held to be an important feeding adaptation and, moreover, serve as a major taxonomic indicator. Indeed, members of the Cercopithecinae are commonly referred to as the "cheek-pouched cercopithecids".

In this paper, I report on cheek pouch use in two species of cercopithecines in the Kibale National Park, Uganda, including: *Cercopithecus ascanius* (redtail monkey) and *Lophocebus albigena* (grey-cheeked mangabey). Three hypotheses for cheek pouch use were evaluated: (1) that the pouches serve a food processing function, (2) that they serve a means by which to reduce interspecific and intragroup feeding competition, and (3) that they provide a means to reduce predation risk by allowing animals to harvest and store food and then retreat to less exposed positions for food processing. Overall, it was expected that cheek pouches would be used most frequently when feeding on fruit because this food resource is (typically) high in simple carbohydrates

(and therefore amenable to cheek pouch amyloidization), patchily distributed in space and time (and thus conducive to feeding competition), and located on terminal branches (and thus only acquired in exposed areas).

Data were collected on habituated animals in Kibale's Kanyawara study area during 1993-1994 and in 1997. Results indicate that cheek pouch use is common and most important in the acquisition and processing of fruit and other patchily but locally abundant food items. In addition, after cheek pouching, both species tended to retreat to denser, more vegetated areas away from exposed terminal branches to process food. There were, however, no obvious effects of an animal's age, sex, or rank on the likelihood of cheek-pouching food.

Information stemming from this work provides insight into the relationship(s) between oral anatomy, feeding behavior, and food resource competition. Implications for recreating the feeding niche occupied by early cercopithecines and the selective pressures that may have shaped this important oral feature will be discussed.

Fetal growth spurts: Fact and fiction regarding the fetal growth curve. M. LAMPL, Emory University, Atlanta. GA 30322, I.M. Bernstein, University of Vermont Medical School, P. Jeanty, Vanderbilt Medical School, D. Walrath, University of Pennsylvania.

Considerable theoretical debate surrounds the importance of biological programming during fetal development at the present time. Few studies have been conducted with the time-intensive longitudinal design that will begin to address the specific questions regarding how growth during fetal development occurs.

Longitudinal study of intrauterine growth from 13 weeks of gestational age to birth were undertaken on a total sample of 50 women. Ultrasonic measurements of multiple fetal parameters were made at intervals ranging from once to three times weekly. Parental anthropometry and smoking history were also taken. These data provide a unique data set for the investigation of the fetal growth process.

Pulsatility in fetal growth patterns are identified that document temporally distinct times of rapid and slow growth. The amplitude and timing of these growth pulses show: (1) distinctive timing of maximal growth rate between individual body parts by gestational age, (2) correlation between related body segments, (3) individually distinctive growth pulse patterns that reflect parental characteristics in terms of body size and body mass index, (4) specific fetal growth pulse patterns associated with indices of maternal nutritional status and smoking.

These data document variability in individual growth curves not accounted for by the generalization that fetal growth rates decrease with age. The variability in growth rates observed in all fetuses suggest a growth pattern in utero when specific time-related expansions and transformations in multiple systems in the organism occur. In addition, parental characteristics modify growth pulse amplitude and frequency, a mechanism through which adaptive growth variation can take place in utero. This is a previously rarely documented observation.

Asymmetry and sexual dimorphism in the human appendicular skeleton. T. E. LANCASTER, Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA 70803

Sexual dimorphism is readily apparent in modern humans. Differences in activity levels are reflected in the skeleton as bones are remodeled in response to the forces placed upon them. Therefore, evidence of a division of labor between the sexes may exist in the skeleton, and analysis of the skeleton can provide information on how limb use in humans has differed and changed over time.

This study compares paired right and left bones of the upper and lower limbs in a sample of 120 individuals from the Hamann-Todd Collection at the Cleveland Museum of Natural History. The individuals sampled ranged in age from 20 - 50 and an equal number of males and females of both blacks and whites were used. The clavicles, humeri, radii, first and fifth metacarpals, femora, tibiae, and first and fifth metatarsals were the focus of the study. The measurements taken on each bone include length, midshaft circumference, and joint surface diameters. Joint surfaces were not measured for the clavicle.

The results are in general, for both sexes, that the bones of the upper limb shows significant asymmetry in contrast to those of the lower limb. This asymmetry is principally seen in the circumference of the bones. One explanation for these results is that bone circumference increases with use and the differing circumferences represent the differential use of limbs. The most notable sexual difference is that the asymmetry in males is predominant in the upper limbs. The greater relative strength in the upper body of males as compared to females is one explanation for these findings. The determination of dimorphism in limb use is most applicable for demographic studies of extinct human populations.

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Biohistory of health and behavior in the Georgia Bight. C.S. LARSEN, North Carolina, Chapel Hill, NC 27599, A.W. CROSBY, Texas, Austin, TX 78712, M.C. GRIFFIN, Moorhead State, MN 56560, D.L. HUTCHINSON, East Carolina, Greenville, NC 27858, C.B. RUFF, M.F. TEAFORD, Johns Hopkins, Baltimore, MD 21205, K.F. RUSSELL, Massachusetts, Dartmouth, MA 02747, M.J. SCHOENINGER, Wisconsin, Madison, WI 53706, L.E. SERING, Michigan, Ann Arbor, MI 48109, S.W. SIMPSON, Case Western Reserve, Cleveland, OH 44106.

Human remains from the Georgia and northern Florida Atlantic coast offer a rich record for tracking and interpreting the biohistory of human populations inhabiting this region of eastern North America. This investigation presents bioarchaeological findings on health and activity from a range of data sets in relation to two major adaptive shifts, the first involving the adoption of maize agriculture in the 11th century A.D. and, the second, the arrival of Europeans and establishment



of mission centers among native populations in the 16th century.

Skeletal samples are drawn from 47 prehistoric and historic-era sites representing 1413 individuals. Specific parameters analyzed include demography (age-at-death), femoral growth velocity, stature, enamel defects, tooth size, dental caries, iron status (porotic hyperostosis), infection (periosteal reactions), physical activity/mechanical stress (osteoarthritis, cross-sectional geometric properties), and trauma.

Temporal comparisons reveal a general increase in infections, dental caries, porotic hyperostosis, and enamel defects (especially microdefects), reflecting an overall decline in health status. Change in osteoarthritis and geometry of long bones indicates a decline in mechanical stress with the shift from foraging to farming, followed by a dramatic increase in mission groups. Long bone structural modifications likely represent the use of native populations as a labor source by the Spanish during the mission period. In general, this region saw a decline in health and well-being throughout the sequence, which is tied to a range of factors—most importantly, dietary change and population aggregation.

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Forelimb posture during quadrupedal locomotion:

Primates compared to nonprimates. S.G. LARSON, University at Stony Brook, Stony Brook, NY 11794, D. SCHMITT, Duke University, Durham, NC 27710, P. LEMELIN, Northeastern Ohio Universities College of Medicine, Rootstown, OH 44272, and M. HAMRICK, Kent State University, Kent, OH 44242

The form of quadrupedal locomotion displayed by primates differs in many ways from that of nonprimate mammals. Qualitative observations have suggested that these differences include a more protracted forelimb at touchdown of walking, and larger forelimb angular excursions. These features may be related to a more compliant gait that minimizes forces during locomotion by increasing contact time and reducing vertical landing velocity. A compliant gait could have played an integral role in primates becoming successful arborealists by permitting the evolution of their characteristic elongated, mobile forelimbs. However, this unique forelimb posture has been documented for only a handful of primate species, mostly semiterrestrial OW monkeys. The present study surveys forelimb posture during quadrupedal walking across the primate Order, as well as for a variety of nonprimate mammals. Forelimb position relative to the trunk was digitized from videotapes of captive animals taken at zoos and research centers.

The results indicate that all quadrupedal primates (including lemuroids, lorisooids, ceboids, cercopithecoids, and hominoids) display a more protracted forelimb at touchdown of a walking step than do nonprimates (taxa examined include various rodents, carnivores and

ungulates). Primates also display a somewhat less retracted forelimb at lift-off. Overall, the differences in forelimb posture during a step result in larger angular excursions for primate forelimbs, an expected characteristic of a compliant gait.

The degree of forelimb protraction in primates appears to be unaffected by either speed or branch inclination. However, body size does appear to influence forelimb posture. Smaller-bodied species display more protracted limbs at touchdown and more retracted limbs at lift-off. Thus, the smaller and more arboreal primates display the largest angular excursions, supporting an association between arboreality and compliant gait.

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Hand positions in human climbing. J.P. LAWRENCE-TAYLER, and J.C. OHMAN, The University of Liverpool, UK.

Since Napier's seminal work in the 1950's, there has been much debate over variations of the human grip, but almost universally within the paradigm for tool-use and manufacture. We departed from such traditional tool-use interpretations, and instead investigated human hand positions and grips during climbing. Much as Napier did for precision and power grips, we found it necessary to first define the basic repertoire of grips available to humans for general, vertical climbing (i.e., *not* brachiation).

From observations on humans climbing rock faces, trees and artificial surfaces we defined many different hand positions and grips. These were distilled into four basic categories: three of which use only the hand ('Grab', 'Push', and 'Jam-Pull'), while the fourth uses both the hand and arm ('Hug'). 'Grab' positions are similar to Napier's 'hammer' or 'power' grip, but may or may not involve the thumb. 'Push' positions use the hand as a stabilizing platform for upward movement. 'Jam-Pull' positions involve jamming the hand, either open- or closed-fisted, into spaces and then pulling, with the hand serving as both pivot and anchor point. 'Hug' involves using the arm with or without the hand. It can be similar in function to the lumberjack method of climbing tree-trunks, but can also involve hanging with an arm around the substrate.

Apes will always be more successful climbers because their relatively longer upper limbs provide a distinct advantage in all 'Hug' positions, and in an arboreal setting their flexed-finger suspensory 'hook' is ideal for 'Grab' grips. However, it became apparent that the human repertoire of hand positions is extremely diverse and adaptable for climbing nonarboreal substrata (e.g., rock faces). This is possible because of thumb utilization during 'Grab' and 'Push' positions, and utilization of the large surface area afforded by expanded thenar muscle mass during 'Grab', 'Push' and 'Jam-Pull' positions. However, while recreational rock climbers do take full advantage of the versatility of the human hand, we must adamantly state that these features of the human hand did *not* evolve as adaptations for climbing during hominid evolution.